A Kaplan turbine with runner diameter 4 m, the discharge is 60 m3/s and hydraulic and mechanical efficiencies are stated to be 90% and 94% respectively. The diameter of boss is 0.1 times the runner diameter and the speed ratio is 0.9. Assuming that discharge is free and there is **no swirl at outlet**; calculate (i) the net available head on the turbine (ii) the power developed and (iii) specific speed.

Q=	60	m3/s	
Do=	4	m	
n=Db/Do=	0.1		
η_h=	90	%	
η_m=	94	%	
Speed ratio, Ku=	0.9		

V_{f1}=	4.82	m/s	(from $Q=(\pi/4)*(Do^2-Db^2)V_{f1}$)
$V_2=V_{f2}=V_{f1}$	4.82	m/s	

(Head utilised by turbine=$(v_{w1}*u_1)/g$= $\mathbf{H-V_2^2/2g=\eta_h H}$), considering no swirl at outlet, $V_{w2}=0$

$H=V_2^2/(2g*(1-\eta_h))$	11.9	m	
Power available at the shaft, Pt=	5905.7	kW	($Pt=\eta_h*\eta_m*\gamma QH$)
runner speed, N=	65.56	rpm	(from u=Ku(2gH)^0.5=pi*D*N/60)

($Ns=NP^{1/2}/H^{5/4}$), in SI unit P is in kW, MKS unit P is in HP

Specific speed, Ns=	228.92

Extra--------cross check for cavitation to install the turbine above TRL

V_2=	**8.00**	* if V_2 is modified
H=	32.6	m
Ha=	10.3	m of water
Hv=	0.26	m of water
σ_c= $1.1*(0.3+0.0032(Ns/100)^{2.73})$	0.36	

* again $\sigma c = V_2^2 \sqrt{}(2gH)$= (Ha-Hv-hs)/H

hs=	1.306017	**above TRL**

A small hydro development, a Kaplan turbine runs under a head of 2.1m. It has a runner of 3.5 m diameter and develops 600 kW at 80 r.p.m. Determine the discharge and specific speed of the machine assuming an overall efficiency of 80%. If a homogeneous turbine is to be tested at a head of 3.0 m and diameter 1.5 m, what are the rotational speed, discharge and power of the unit?

Hp=	2.1	m	p=prototype
Dp =	3.5	m	m=model
Pp =	600	kW	
Np =	80	r.p.m.	
ηo =	0.8		
Dm =	0.5	m	
Hm=	1	m	
Qp = ($P_p=\eta_o\gamma Q_p H_p$ in W)	36.41	m^3/s	
$N_{sp}= N_p P_p^{1/2}/H_p^{5/4}$	775.16		

for homogeneous turbine, i.e. for model

$N_m = (gH/N^2D^2)_m=(gH/N^2D^2)_p$	386.44	r.p.m.	
$Q_m = (Q/ND^3)_m=(Q/ND^3)_p$	0.51	m^3/s	
$P_m = (P/\rho N^3D^3)_m=(P/\rho N^3D^3)_p$	4.0	kW	

In a hydroelectric power plant 12 MW is required. A Kaplan turbine develops works at 195 rpm under 12 m head and with an overall efficiency of 85 percent. The geometric and flow parameters are as follows: speed ratio (based on outer diameter) is 2.0, flow ratio is 0.63, and diameter of the boss is 35 percent of external diameter of the runner. Find the specific speed of the turbine and number of turbine needed to fulfill the power requirement. Also, find the minimum safe elevation of the runner to avoid cavitation taking vapour pressure 0.3 m of water.

Power to be developed , **P_T**=	12	MW		
Kaplan turbine N =	195	rpm		
H =	**12**	m		
ηo =	0.85			
speed ratio Ku =	2			
flow ratio Kf =	0.63			
Db/Do =	0.35			
Pv=	0.3	m of water		

Ns = ?

No of turbine = ?

u_1= Ku√(2gH)	30.69	m/s		
Do= ($u_1=\pi D_o N/60$)	3.01	m		
Db=	1.05			
flow vel Vf = K_f√(2gH)	9.67	m/s		
Q = $\pi/4*D_o^2(1-n^2)V_{f1}$)	60.20	m^3/s	60.20	m^3/s
P by one kaplan = $\eta_o \gamma QH$	6023412	W		
No of turbine = **P_T/P**	2.0	round c	**2**	2
Specific speed Ns = $Ns=NP^{1/2}/H^{5/4}$)	677.6			
σ_c= $1.1*(0.3+0.0032(Ns/100)^{2.73}$)	0.98			

* from $V_2^2/2gH= \sigma =(H_a-H_v-hs)/H$, where H_a= 10.3 m of water

* for minimum elevation $\sigma=\sigma_c$

hs=	-1.80	m	**excavation needed**

A hydroelectric power station required to generate 60000kW at 50 cycle frequency and at an available head of 20 m. Designer suggests the use of Kaplan turbine for which specific speed is 600. Make calculations for (a) the speed and discharge through the turbine assuming that it has an overall efficiency of 90%, (b) leading dimensions of the turbine assuming flow ratio 0.6 and that hub diameter of the wheel is 0.35 times the outer diameter, (c) maximum safe elevation of runner to avoid cavitation taking vapour pressure 0.26 m of water and critical value of thoma's cavitation factor 0.7.

power station required to generate , Pt =	60000	kW
frequency f =	50	cycle or hz
head available H =	20	m
Kaplan turbine specific speed Ns =	600	
ηo =	0.9	
flow ratio Kf =	0.6	
n = Db/Do =	0.35	
vapour pressure Hv =	0.26	m of water
critical thoma's cavitation factor σ_c =	0.7	

N = ($Ns=NP^{1/2}/H^{5/4}$)	103.60	rev/min	
no of piar of pole p = P=60*f/N	28.96		**30** (adopted to make the speed synchronus)
Q = ($Pt= \eta_o \gamma QH$)	339.79	m^3/s	
$V_{f1} = K_f \sqrt{(2gH)}$	11.89	m/s	
Do = ($Q= \pi/4*D_o^2(1-n^2)V_{f1}$)	6.44	m	
Db = ($n = D_b/D_o$)	2.25	m	

* from $V_2^2/2gH= \sigma =(H_a-H_v-hs)/H$, where H_a= 10.3 m of water
* for minimum elevation $\sigma=\sigma_c$

hs = **-3.96** m

* -ve value means turbine to be installed below the tail race level

KE head at draft tube inlet = $V_{f1}^2/2g$ 7.2 m

Turbine to be placed at (hs-KE head at draft tube inlet)

-11.16 m **below tail race**